REMARKS

This is a Response to the Office Action mailed August 25, 2009, in which a three (3) month Shortened Statutory Period for Response has been set, due to expire November 25, 2009. Thirty-two (32) claims, including four (4) independent claims, were paid for in the application. No new matter has been added to the application. No fee for additional claims is due by way of this Amendment. The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090. Claims 33-47 and 49-61 are pending.

Information Disclosure Statement

Applicants filed a Supplemental IDS on June 5, 2009. It is respectfully requested that an initialed copy of the IDS be provided to Applicants to confirm consideration thereof.

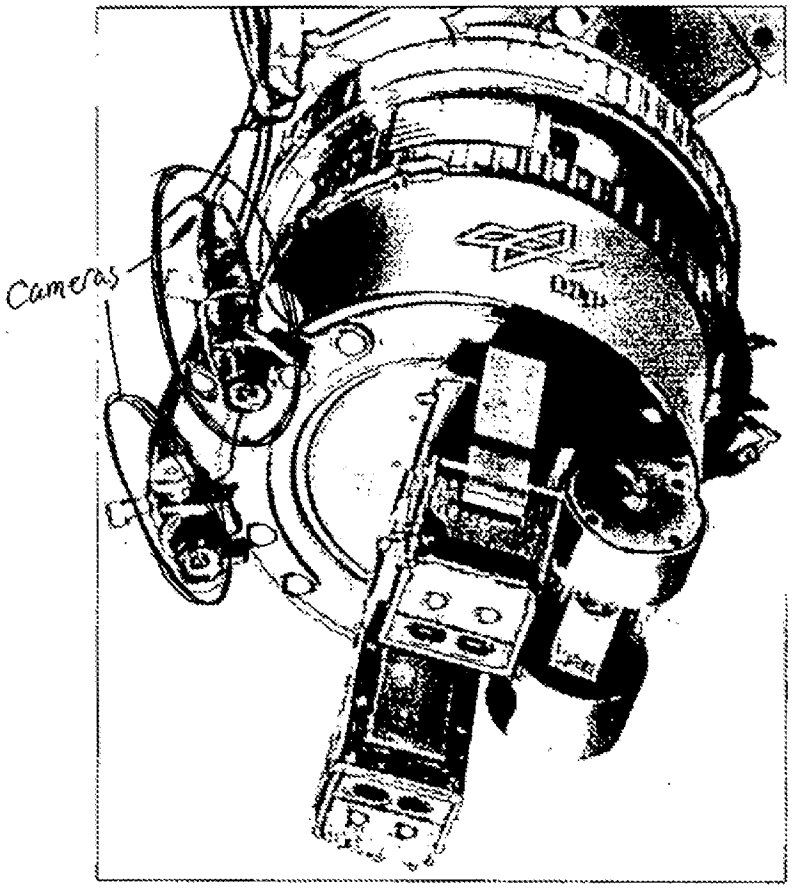
35 U.S.C. §102(b) Rejections

Claims 33-47 and 49-61 were rejected under 35 U.S.C. §102(b) as being anticipated by Multisensory Visual Servoing by a Neural Network by Wei et al. (hereinafter "Wei").

Claim 50 is independent so will be discussed before the claims that depend therefrom. Claim 50 recites:

> A method useful in three-dimensional pose estimation for use with a single camera mounted to a movable portion of a robot, the method comprising:
> capturing a two-dimensional image of a volume containing a target object;
> locating a number of features in the captured image of the target object; and
> determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image and an algorithm that employs a known or determinable physical relationship between at least some of the located features.

The Office alleges that Wei teaches all of the elements recited by claim 50, relying on Figures 2-3 of Wei. However, Figure 2 refers to cameras in the plural. Figure 3 shows two cameras. See Wei, at page 4 bottom of first column-top of second column, Figure 3, and page 1, second column. Figure 3 is reproduced below, in which circles have been added to identify the two stereo cameras.



The Office also relies on Figure 4 of Wei. However Figure 4 illustrates *stereo* images produced from the two cameras.

It is clear that Wei does not teach or suggest "[a] method useful in three-dimensional pose estimation for use with a *single camera* mounted to a movable portion of a robot, as recited by claim 50. (Emphasis added.) It is also clear that Wei does not teach or suggest "determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features *using only the single captured*

image and an algorithm that employs a known or determinable physical relationship between at least some of the located features." (Emphasis added).

Claim 33 is dependent from claim 50 and further recites "capturing a number of images of a calibration object by the camera; determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame." The Office alleges that such is taught by Wei, relying on page 1, column 1. However, the cited portion of Wei actually appears to teach away from such (*e.g.* "On the contrary, a neural network approach for doing the same job can avoid all such calibrations and provides convenient sensor fusion framework. The network learns the direct transformation from (multi-) sensory data to the required motions based on a set of examples. The effects of sensor calibration, geometric transformation, and the relative importance of each sensor are all absorbed in a single network.").

Claim 35 is indirectly dependent from claim 50 and further recites "positioning the camera orthogonally with respect to a ruled template with a number of features, where a known or determinable physical relationship exists between at least some of the features." The Office contends that Wei teaches such, relying in particular on table II, and by interpreting table II to be a template. Applicants respectfully contend that a table in a printed publication cannot be reasonably interpreted to constitute a ruled template with a number of features. In any case, Wei clearly does not teach or suggest positioning a camera orthogonally with respect to such table.

Claim 37 is indirectly dependent from claim 50 and further recites "capturing a number of images of a calibration object by the camera comprises capturing at least one image at each of a plurality of positions spaced perpendicularly from the calibration object." The Office alleges that Wei teaches such, replying on Figures 2-4. Figure 2 illustrates the overall system, while Figure 3 shows an end effecter with two cameras in a stereoscopic arrangement and

number of laser range finders. Figure 4 illustrates stereo images as captured by the two cameras. (Note, since the two cameras are not parallel, than it is impossible for both cameras to be perpendicular to an object at a same time.) The positions of the cameras do not appear to be perpendicular with respect to the object. In any case, Wei clearly does not teach capturing a number of images at *a plurality of positions spaced perpendicularly from the calibration object*" (emphasis added) as recited by claim 37.

Claim 39 is indirectly dependent from claim 50 and further recites "determining at least one of a focal length, a first order radial lens distortion coefficient, a set of coordinates of a center of a radial lens distortion, or a scale factor indicative of a framegrabber scanline resampling uncertainty." The Office alleges that such is taught by Wei, but does not identify any specific portion of Wei. Upon review of Wei, Applicant's attorney has not found any teaching of such in the cited reference. Applicants respectfully ask that the Office specifically point out such teaching, if the Office persists in this rejection.

Claim 40 is indirectly dependent from claim 50 and further recites that "determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes." The Office alleges that such is taught by Wei, relying on page 1, col. 1, second paragraph, and figures 2-3. However, the cited portion of Wei actually appears to teach away from such (*e.g.* "On the contrary, a neural network approach for doing the same job can avoid all such calibrations and provides convenient sensor fusion framework. The network learns the direct transformation from (multi-) sensory data to the required motions based on a set of examples. The effects of sensor calibration, geometric transformation, and the relative importance of each sensor are all absorbed in a single network.").

Claim 41 is indirectly dependent from claim 50 and further recites "determining a camera space-to-tool space transformation based at least in part on at least two of the number of

images captured by the camera of the calibration object." The Office alleges Wei teaches such, relying on Figures 2-4. Figure 2 illustrates the overall system, Figure 3 shows an end effecter carrying a pair of cameras and laser range finders, and Figure 4 shows a stereo images captured by the pair of cameras. Applicant does not see how the Office could possible infer such details of operation (*i.e.,* determining a camera space-to-tool space transformation based at least in part on at least two of the number of images captured by the camera of the calibration object) from such high level Figures.

Claim 42 is indirectly dependent from claim 50 and further recites "determining a camera space-to-tool space transformation based on single one of the number of images captured by the camera of the calibration object and on a number of physical coordinates of at least one feature of the calibration object." The Office alleges Wei teaches such, relying on Figures 2-4. Figure 2 illustrates the overall system, Figure 3 shows an end effecter carrying a *pair of cameras* and laser range finders, and Figure 4 illustrates *stereo* images captured by the *pair of cameras*. Such cannot possibly teach or suggest , "determining a camera space-to-tool space transformation based on *single one of the number of images captured by the camera* of the calibration object and on a number of physical coordinates of at least one feature of the calibration object" as recited in claim 42 (emphasis added). Wei simply does not teach or suggest a single camera single image approach to robotic machine-revision.

Claim 43 is dependent from claim 50 and further recites, *inter alia*, "selecting a number of features from the captured image of the teaching object; and determining a set of object space coordinates for each of the selected features from the captured image of the teaching object." The Office alleges Wei teaches such, relying on page 2, col. 1 and Figure 4. However, the cited portion does not appear to refer to features, let alone "selecting features and determining object space coordinates for each of the selected features" as recited in claim 43. The cited portion is directed to training and with dealing with inexactness of mapping through a recursive method.

Claim 44 is indirectly dependent from claim 50 and further recites "selecting a number of features from the captured image of the teaching object comprises selecting six features from the captured image of the teaching object." The Office alleges Wei teaches such,

again relying on page 2, col. 1 and Figure 4. However, the cited portion does not appear to refer to features, let alone "selecting six features from the captured image of the teaching object" as recited in claim 44.

Claim 45 is indirectly dependent from claim 50 and further recites "determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame." The Office alleges that Wei teaches such relying on page 2, col. 1, and Figures 2-4, "wherein reference frame has been considered as position frame." It appears that the Office is employing the "position frame" to be both the object space reference frame and the camera space reference frame. Such is of course incorrect since two different reference frames have been recited, and the Office cites to at most a single reference frame in its rejection.

Claim 46 is indirectly dependent from claim 50 and further recites "determining a position and an orientation of an object frame in the tool frame reference frame based at least in part on the object frame-to-camera space and camera space-to-tool space transformations." The Office alleges that Wei teaches such relying on pages 1-22, the abstract, and Figures 2-4. While Wei mentions a transformation, the cited passages do not appear to describe the various transformations or various reference frames recited in claim 46.

Claim 47 is indirectly dependent from claim 50 and further recites "providing the position and orientation of the object frame to the robot; and training an intended operation path inside the object frame." The Office alleges that Wei teaches such relying on Figure 4 and the abstract. As previously explained, Figure 4 illustrates stereoscopic images captured by a pair of cameras. The abstract discuss camera calibration and sensor to hand calibration (*e.g.*, camera to end effecter). The abstract further discusses supplying sensor data to a multilayer feed forward neural network to associate the direct transformation for the sensory data to required motions, which avoids the need for network retaining. There is no discussion of providing position and orientation of an object frame to the robot or of training an intended operation path inside the object frame, as opposed to any other possible reference frame. In fact, it appear that only small portions of motions M are provided to the robot, and without more, one can only assume that those are in a robot frame of reference.

Claim 49 is dependent from claim 50 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features; and capturing another two-dimensional image of the volume containing the target object before determining the object space-to-camera space transformation for the target object." The Office alleges that Wei teaches such relying on page 2, col. 1, and Figure 2-4. Applicant's attorney has carefully reviewed the cited passage, and cannot find any reference to features or to the number of located features, let alone adjusting a position in response to the number of features being insufficient or capturing an additional image in response to the same.

Claim 51 is dependent from claim 50 and further recites "determining at least one movement of the robot that orients the camera orthogonally with respect to the target object based at least on part on the object space-to-camera space transformation." The Office alleges that such is taught by Figure 4 of Wei. However, Figure 4 illustrates stereo images which appear to have a random orientation with respect to the workpiece. There is nothing in Figure 4 that would suggest an orthogonal orientation between the camera and the workpiece.

Claim 52 is dependent from claim 50 and further recites "determining a position of the object frame in the tool space reference frame; and providing an object frame to the robot." The Office alleges that such is taught by Wei, relying on page 2, col. 1, and Figures 3 and 4. While Figure shows an image of an object, such is not the same as the recited "object frame" not the recited "providing an object frame to the robot." Likewise, while Figure 3 shows an end effecter portion of a robot, such is not the same as the recited "providing an object frame to the robot." In column 1 of page 2, Wei discusses training a neural network and dealing with inexactness of mapping. According to the cited passage, only a small portion of M_1 is sent to the robot, where M_1 is an amount of motion of the robot hand with respect to the reference position and the sensory data which was recorded after each motion. Wei, page 2, col. 1. Thus, there is no basis to allege that Wei teaches "determining a position of the object frame in the tool space reference frame; and providing an object frame to the robot" as recited by claim 52.

Claim 53 is independent and recites, *inter alia,* "a single camera operable to capture a number of images of a calibration object" "determining an object space-to-camera

space transformation based at least in part on a position of at least some of the located features in solely the captured image using an algorithm that employs a known or determinable physical relationship between at least some of the located features." The Office alleges that Wei teaches such. As previously explained, Wei is clearly teaches the use of two cameras to produce stereo images. Thus, Wei is inapposite with respect to the single camera approach recited in claim 53.

Claim 54 is dependent from claim 53 and further recites, *inter alia,* "determining a set of object space coordinates for each of the selected features from the captured image of the teaching object" and "determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame." The cited passage of Wei (*i.e.*, page 2, col. 1) does not each such. The cited passage at most teaches sending only a small portion of M_1 to the robot, where M_1 is an amount of motion of the robot hand with respect to the reference position and the sensory data which was recorded after each motion. Wei, page 2, col. 1.

Claim 57 is dependent from claim 53 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features." The Office alleges such is taught is page 2, col. 1 of Wei. Applicant's attorney has carefully reviewed the cited passage, and cannot find any reference to features or to the number of located features, let alone adjusting a position in response to the number of features being insufficient.

Claim 58 is independent recites, *inter alia*, "a single camera operable to capture a number of images of a calibration object;" and "determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features using the captured image without any additional captured images and an algorithm that employs a known or determinable physical relationship between at least some of the located features."

As previously explained, Wei is clearly teaches the use of two cameras to produce stereo images. Thus, Wei is inapposite with respect to the single camera approach recited in claim 58.

Claim 61 is dependent from claim 58 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the

target object is determined to be an insufficient number of features." The Office alleges such is taught is page 2, col. 1 of Wei. Applicant's attorney has carefully reviewed the cited passage, and cannot find any reference to features or to the number of located features, let alone adjusting a position in response to the number of features being insufficient.

Conclusion

Applicants respectfully submit that the pending claims are in condition for allowance. Any remarks in support of patentability of one claim should not be imputed to any other claim, even if similar terminology is used. Any remarks referring to only a portion of a claim should not be understood to base patentability on that portion; rather, patentability must rest on each claim taken as a whole. A number of clarifying amendments have also been made to the above claim set. Applicants do not acquiesce to each of the Examiner's rejections and to each of the Examiner's assertions regarding what the cited references show or teach, even if not expressly discussed herein. Although changes to the claims have been made, no acquiescence or estoppel is or should be implied thereby; such amendments are made only to expedite prosecution of the present application and are without prejudice to the presentation or assertion, in the future, of claims relating to the same or similar subject matter.

If the undersigned attorney has overlooked a relevant teaching in any of the references, the Examiner is requested to point out specifically where such teaching may be found. In light of the above amendments and remarks, Applicants respectfully submit that all pending claims are allowable. Applicants, therefore, respectfully request that the Examiner reconsider this application and timely allow all pending claims. The Examiner is encouraged to contact the undersigned by telephone to discuss the above and any other distinctions between the claims and the applied references, if desired. If the Examiner notes any informalities in the claims, the Examiner is encouraged to contact the undersigned by telephone to expediently correct such informalities.

Respectfully submitted,

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